

Appl. No. 10/587,701
Ansdt. Dated 15 May 2009
3Reply to Office action of 28 November 2008
Atty. Docket No. AP893USN

REMARKS/ARGUMENTS

Applicant acknowledges, with thanks, the allowance of claims 8 and 17.

Regarding paragraph 2 of the Office Action, the word "of" has been substituted as suggested by the examiner. The suggested amendments to claim 15 have not been made because they have been rendered moot by more extensive amendments to the claim in the process of rewriting it in independent form.

In paragraphs 7 and 8 of the Office Action, the examiner indicated that claims 3, 6, 12 and 15 would be allowable if rewritten in independent form to include the limitations of the base claim and any intervening claims and, in the case of claims 3 and 6, to overcome objections set forth in the Office Action. Claims 3, 6, 12 and 15 have been rewritten as required and so are in allowable condition.

Rejection of claims 1, 9 and 10 under 35 U.S.C. 103(a)

In paragraph 4 of the Office Action, claims 1, 9 and 10 were rejected under 35 U.S.C. 103(a) as unpatentable over US 2004/0146024 (Li'024) in view of US 6,795,392 (Li'392). Applicant respectfully traverses this rejection.

The systems disclosed in the references Li'024 and Li'392 cannot be combined without modification of one or both to such an extent that it/they would be rendered unsuitable for their intended purpose.

Li'024 is specifically concerned with CDMA systems, and discloses embodiments that make use of features specific to such CDMA wireless systems (such as code correlation). Conversely, Li'392 is specifically concerned with OFDM systems and discloses embodiments that make use of features specific to such OFDM wireless systems. A person of ordinary skill in this art would not look to an OFDM receiver for help in solving a problem relating to a CDMA system, or vice versa, since the CDMA and OFDM are wholly different types of communication system.

A comparison of Fig. 2 of Applicant's specification and Fig. 1 of Li'024 shows that the main difference lies in the addition of joint detectors to the right of the processing chain. The use of the terminology "joint detector" clearly refers to a CDMA-type system, where the use of codes which, in principle, should be orthogonal among themselves does not necessarily warrant joint processing or interference suppression. In other words, the CDMA concept itself was

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intended to make interference suppression unnecessary since simply passing the signal through a filter matched to the code (or correlator) would reduce all other signals to white noise. However, it was found in "real world" systems that this was not always the case (because of the near-far effect, or loss of orthogonality between codes due to channel effects or other); hence the development of joint detection techniques in this context.

Regarding claim 1, the Office Action asserted that the following portion:

« An array receiver for processing signals from a plurality of transmitting users via an array antenna having an array of N antenna elements providing a set of antenna signals, each comprising information from each user, wherein said receiver has a common preprocessing section for sampling each of the antenna element signals... »

read onto Fig. 2 and paragraph [0022] of Li'024. With all due respect, the similarity is superficial; when the structure and functionality of the preprocessing section are considered, it is apparent that they are not the same.

Regarding the following extract of claim 1:

« and processing the samples of at least some of said antenna signals $i[n]$ to form a plurality of basis signals $d[n]$ together having fewer space-time dimensions than the space-time dimensions of the combined antenna signals... »,

the Office Action asserted that one skilled in the art would recognize that the number of antennas can be more or less regardless of the number of users as disclosed by Li'392 (col. 3, lines 20-24).

With all due respect, the relationship between the number of antennas and the number of users is not relevant to the above portion of the claim. What is stated there is that the preprocessing section effects a reduction in the total number of *space-time* dimensions (as defined in general by the number of antennas and the memory length – defined by the delay spread with respect to symbol duration – of the channels) which will be forwarded for further processing, thus enabling a reduction in processing complexity.

It should also be noted that, as illustrated in Fig. 1 of Applicant's application, Applicant's preprocessing section derives each of the basis function outputs as a function of all antennas. This is different from Li'024, where no cross-coupling of antenna signal paths occurs before the spatial combiner blocks.

Likewise, no direct relationship is observed in Li'392. Although the latter makes use of an

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eigen-matrix approach and thus derives basis functions, they are used for channel estimation in frequency, a prerequisite to equalization in OFDM systems, which is unrelated to interference reduction. In Applicant's preprocessing section, the basis functions are derived over space and time (not frequency) and serve to separate multiple user signals (thus combatting mutual interference) with reasonable complexity.

The Office Action then equated the "plurality of signal processing units" of claim 1 to joint detectors. They are not joint detectors, either in the CDMA sense or otherwise. Moreover, they cannot be equated to the spatial combiners in Li'024 (box 212 in Fig. 2) because no code correlation occurs ahead of the said signal processing units. In effect, the job of the spatial combiners in Li'024 is split up between the preprocessing section and the downstream signal processing units in Applicant's system. Also, no code correlation occurs in Applicant's system, since Applicant assumes no foreknowledge of any such signal characteristic.

The Applicant's signal processing units perform beamforming and nulling and produce "a respective one of a set of estimated received signals each for a corresponding one of the users." This is then routed to a classical detection device (80/0 through 80/M in Fig. 1 of Applicant's patent specification), not to a joint detector as in Li'024.

Yet another difference is that the basis functions which are input to each spatial combiner are not necessarily produced using foreknowledge of codes (such as code correlation, box 206 in Li'024), but can rely solely on knowledge of channels (delay profile, spatial signature, etc.) to maximize energy related to a specific user.

Also, each signal processing unit in the Applicant's specification takes all basis functions as inputs to perform the beamforming and nulling, instead of solely the signals related to one user (as in Li'024). In Li'024, the mention of maximizing energy in paragraph [0038] relates to the spatial signatures used in computing weights for the spatial combiners. This is not relevant to Applicant's maximizing of energy in the basis functions, which are produced by the preprocessing section.

Another major difference as compared with Li'024 is that, in Applicant's specification, joint processing occurs both in the preprocessing section (of all antenna signals, with the goal of reducing the total number of dimensions for further processing, thus affording opportunities for reduced computational complexity), and in the signal processing sections.

It is clear, therefore, that the statement in the Office Action "Therefore, by simply

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providing a large number of antennas with a smaller number of detected users..." is irrelevant.

In view of these many differences, even in the unlikely event that a skilled person were to try combining the two references Li'024 and Li'392, the end result would not be the system of Applicant's claims 1, 9 and 10. It is submitted therefore that claims 1, 9 and 10 are patentable over the applied references.

Rejection of claims 1, 2, 4, 5, 7, 9-11, 13, 14 and 16 under 35 U.S.C. 103(a)

In paragraph 5 of the Office Action, claims 1, 2, 4, 5, 7, 9-11, 13, 14 and 16 were rejected under 35 U.S.C. 103(a) as unpatentable over US 6,301,293 (Huang) in view of US 6,934,323 (Hara) and US 6,795,392 (Li'392). This rejection is respectfully traversed.

It should be observed first and foremost that both Huang and Hara are clearly CDMA-specific disclosures.

Again, the preprocessing section in Huang (box 16 in Fig. 2) assumes some foreknowledge of codes, using such codes to extract each resolvable path in a standard RAKE receiver structure. While this preprocessing section might produce signals which "maximize energy" for each user, it does so by relying on foreknowledge of codes, and the very wide bandwidth of CDMA signals (which makes for resolvable paths) enables a nice reduction in the number of dimensions, i.e., no equalization is required beyond the preprocessing section. This is not possible in the general case.

In Applicant's specification, the basis functions (y_0, \dots, y_M) are actually vectors as indicated by the bold type notation. This indicates that there might be more than one output signal from the preprocessing section associated with any one user. The number of such signals is determined according to the severity (i.e. memory length) of the channel, as well as the desired cost / complexity tradeoff.

Hara discloses a two-step structure which might at first glance seem similar to that disclosed in Applicant's specification and claimed in claim 1. As mentioned above, however, in "real world" CDMA applications it has been found that the orthogonality between codes could not be maintained, and thus, that some correlation could be observed at the receiver which was often detrimental to performance. Hara's solution is to "decorrelate" the signatures in the preprocessing step. This is very different from the present invention. Again, no foreknowledge of codes or CDMA context is assumed. Furthermore, the preprocessing section seeks to produce

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signals which "maximize" energy for each user, irrespective of any other signals / interference which might be present. In other words, no joint processing (in terms of user signals) occurs in the preprocessing section.

Furthermore, the Office Action states on page 6: "... wherein it is clear that the MMSE criterion would obviously exhibit a desired optimized concentration of energy of that desired user's received signal." With all due respect, this is not so. The MMSE criterion maximizes the signal-to-(interference-plus-noise) ratio; not the signal energy itself.

The goal is to produce a number of basis functions for further processing. The preprocessing does not therefore tackle interference in any way, but leaves that job to the subsequent signal processing sections. The use of the MMSE criterion necessarily implies a direct attack on interference.

Regarding claim 2, the Office Action further asserts that the adjustment of parameters in dependence upon channel characteristics is obvious based on Huang and Hara. Again, it should be noted that the channel parameters updated in Huang are the resolvable path gains, in a purely CDMA-specific context. The Office Action then states "... that would obviously be updated in the similar way as of the updating of eigenvector in Hara, see col. 11, lines 1-5, which clearly suggest that the eigenvector / weight is updated for every sampling period in dependence upon channel characteristics of all user channels with the correlation matrix ϕ ". Again, no correlation matrix is invoked in the present invention, and such a correlation matrix necessarily involves knowledge of the users' codes in a CDMA context.

Regarding claim 4: The claim is dependent upon claim 1 and so patentable with it. Moreover, the Office Action states "Huang teaches that the number of basis signals is equal to the number of desired user signals." This is not quite correct, and not in line with the Fig. 1 of the Applicant's patent application.

The Office Action also states (on page 7):

"Regarding claim 5, the claim is rejected for the same reason as set forth in claim 1 above. In addition, it is clear the common preprocessing section [...] would comprise (k users) dominant subspace filters and would produce a set of basis signals that would obviously project the input signal of nth user carrying the most energy to the output of the nth basic signal as claimed (i.e. obtained via matched filter and weighted coefficients as an obvious desired result for any filter design

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intended for a multi-user detection)."

Again, this presumes a CDMA context. There is no matched filter or correlator anywhere in the Applicant's preprocessing section, since Applicant assumes neither foreknowledge of user codes nor a CDMA context. Also, the difficulty of the problem is different in a non-CDMA context. The multi-user structure of Huang, for example, can rely on the codes as a first processing step (matched filter bank) thus considerably reducing interference, and also on the resolvable paths afforded by the large bandwidth of CDMA signals to avoid any form of explicit equalization. In general, a non-CDMA array receiver would also have to perform equalization and the number of taps to adapt would be proportional to both the number of antennas and the memory length of the channel (and thus could be considered excessive, in terms of computational complexity). Thus, the preprocessing section aims to reduce this excessive number of dimensions by producing a certain number of basis functions, based on channel knowledge alone, (as specified by claim 2), and not on any user codes (although user codes could be exploited to gain such channel knowledge).

It is submitted, therefore, that claims 1, 2, 4, 5, 7, 9-11, 13, 14 and 16 are patentable over Huang, Hara and Li'392 whether taken individually or in combination.

Accordingly, it is submitted that all claims of record are patentable and early and favourable reconsideration of the application is respectfully requested.

Respectfully submitted



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